

Monte Carlo Comparison of RPCs and Liquid Scintillator

- RPCs with 1-dimensional readout (generated by RR) and liquid scintillator with no pulse height (generated by PL/LM) should give similar results.
- Comparing results serves as a useful cross check for RPC and liquid simulations.
- Detailed description of custom container implemented in GEANT.
 - Plywood absorber
 - 12 double gap RPCs modules per container
 - 6 RPCs per module (3 wide x 2 deep)
 - 5 mm dead space around edge of each RPC
 - X & Y readout strips (can be used as X or Y at analysis stage)
 - Cross-talk between strips included.
 - Using beam file for 820 km, 10 km off-axis.
- Generating large samples of events on the farm:
 - $\nu_\mu \rightarrow \nu_e$
 - ν_μ CC
 - ν_μ NC
 - Beam ν_e

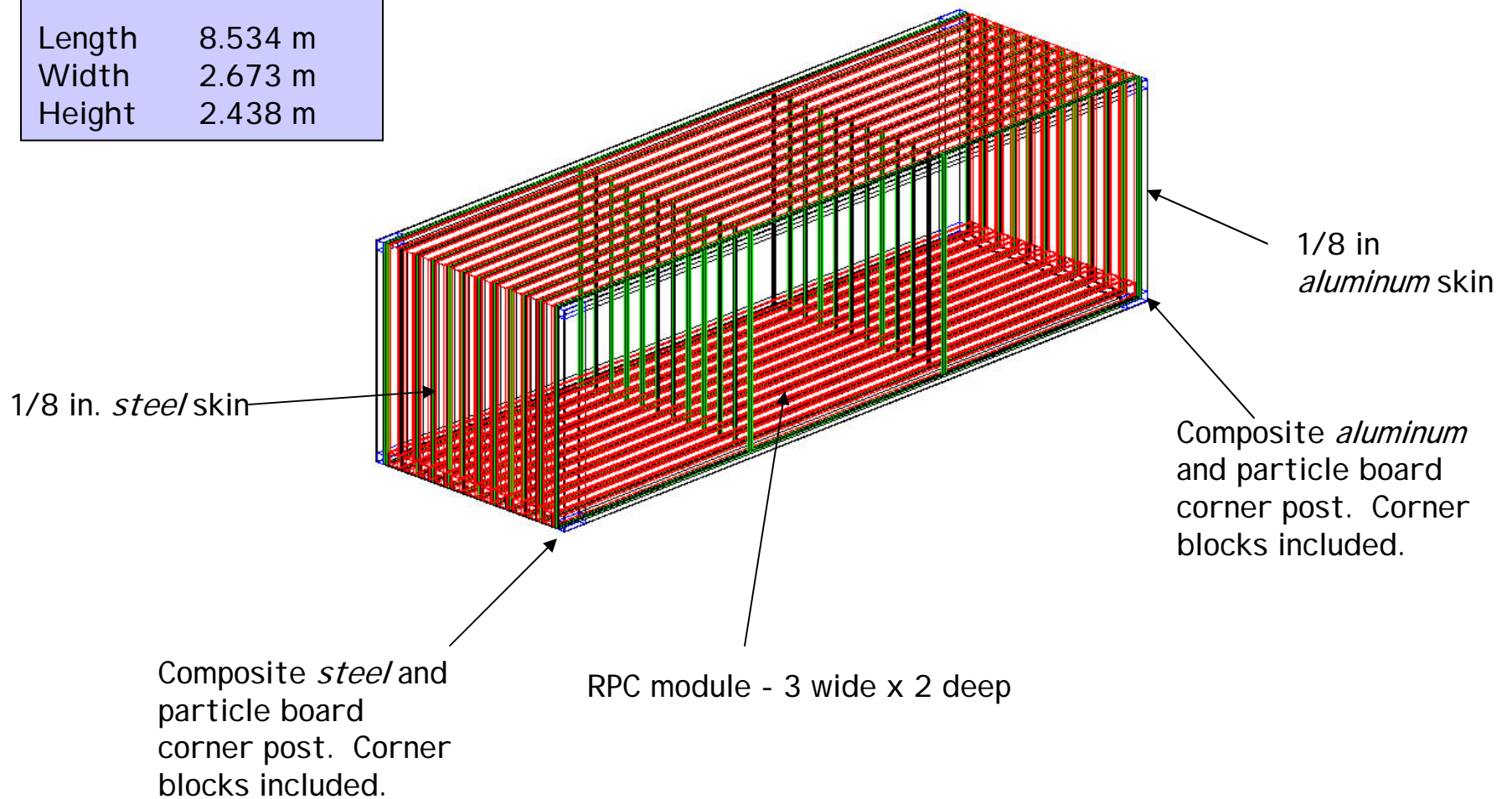
General Strategy

- Implement custom container description in GEANT.
- Use NEUGEN3 event generator with a flat energy distribution
- Weight interaction vertex in GEANT by number of target nucleons in various materials
- Parabolic fit to multiple tracks in an event.
- Weight final distributions by evolved beam spectra.

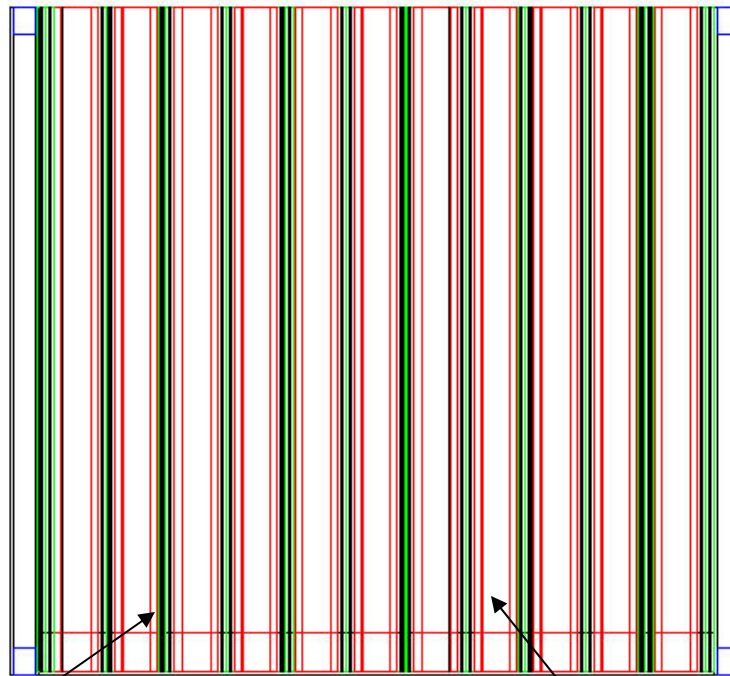
GEANT Implementation

Container Dimensions

Length	8.534 m
Width	2.673 m
Height	2.438 m



Side view



RPC Modules
12 modules in all
Modules include 6 RPCs (3 wide by 2 deep)

Ignore Y strips for odd numbered modules
Ignore X strips for even numbered modules

Plywood Absorber
11 full layers + 2 half layers
Full layers 15.24 cm thick, $\sim 28\% X_0$

50 kton Detector

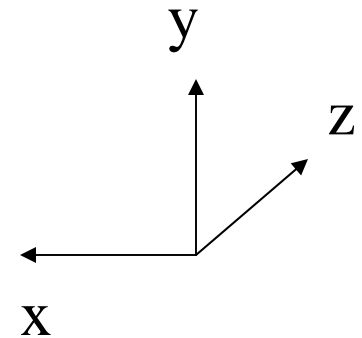
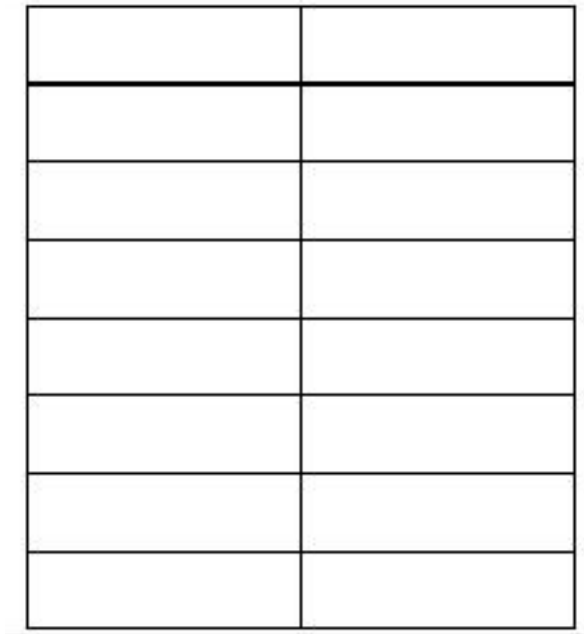
2 X 8 X 75 Stack of Containers

1/2 in. vertical gap between
RPC modules in adjacent
containers

3/8 in. horizontal gap between
RPC modules in adjacent
containers

RPCs have a 5 mm dead space
around outer edge. → 1 cm
dead space between the set of 3
RPCs in each plane.

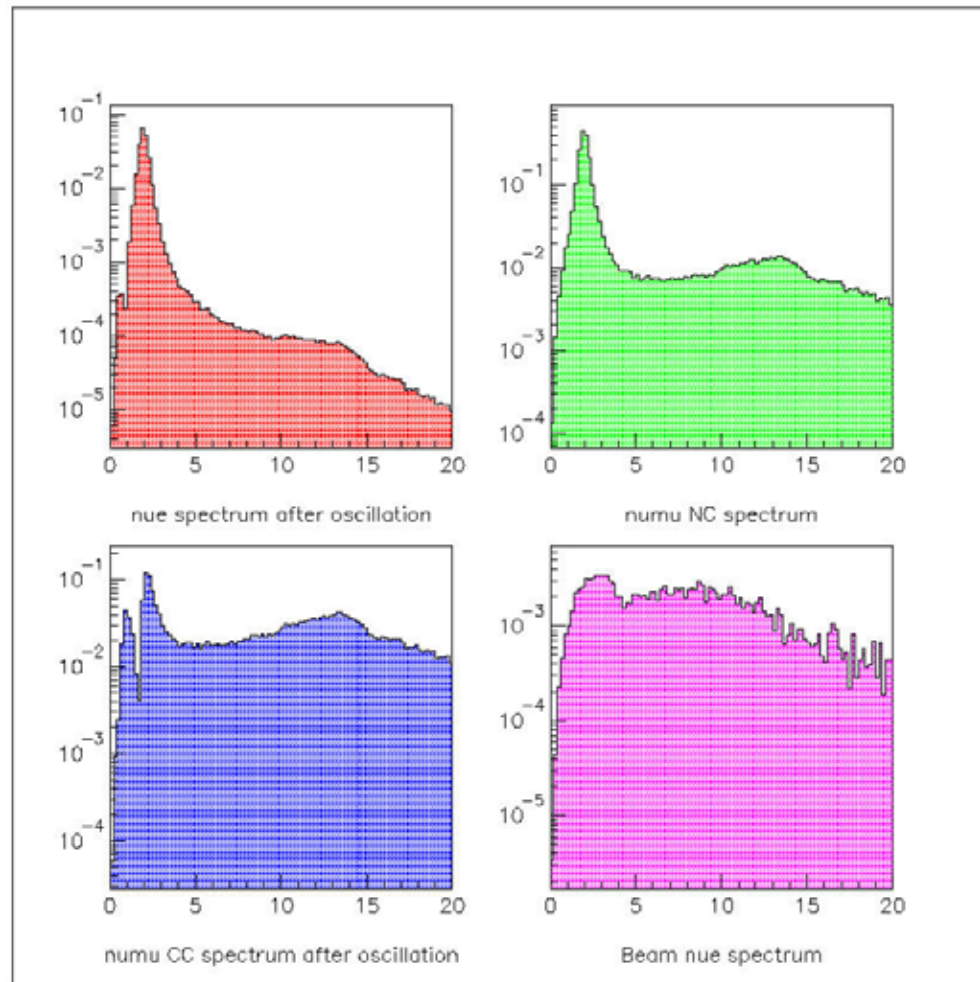
2 in. gap between containers in Z



Evolved Neutrino Energy Spectra

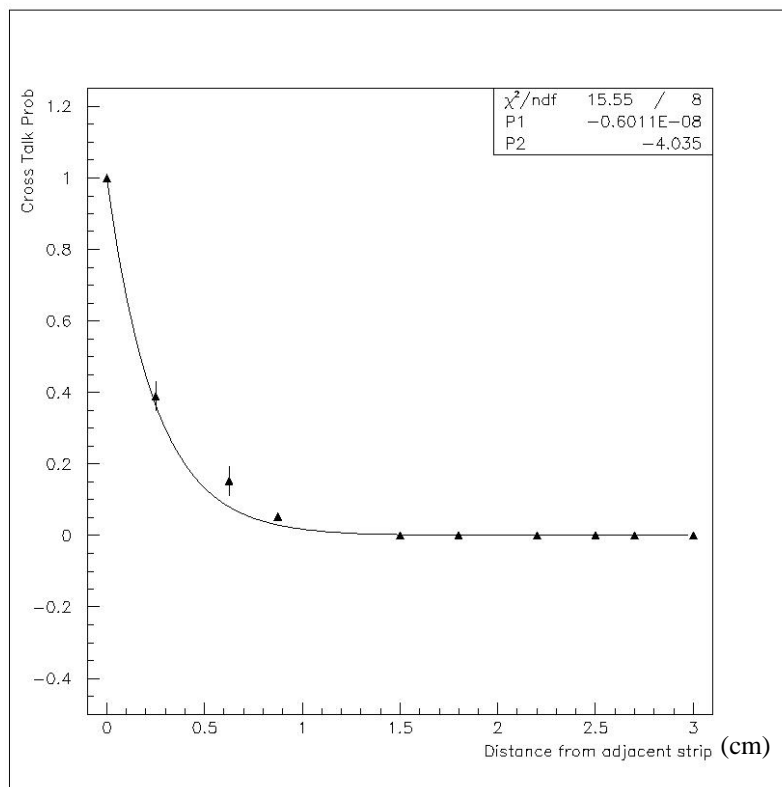
Flat neutrino spectrum generated between 0.1 - 3.5 GeV for ν_e and 0.1 - 20 GeV for ν_μ and Beam ν_e .

Weight applied at ntuple level.

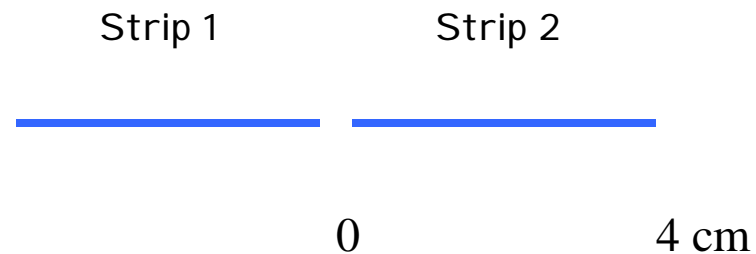


Cross Talk (Charge Sharing) Implemented in GEANT

Cross talk is one of the biggest differences between the two technologies

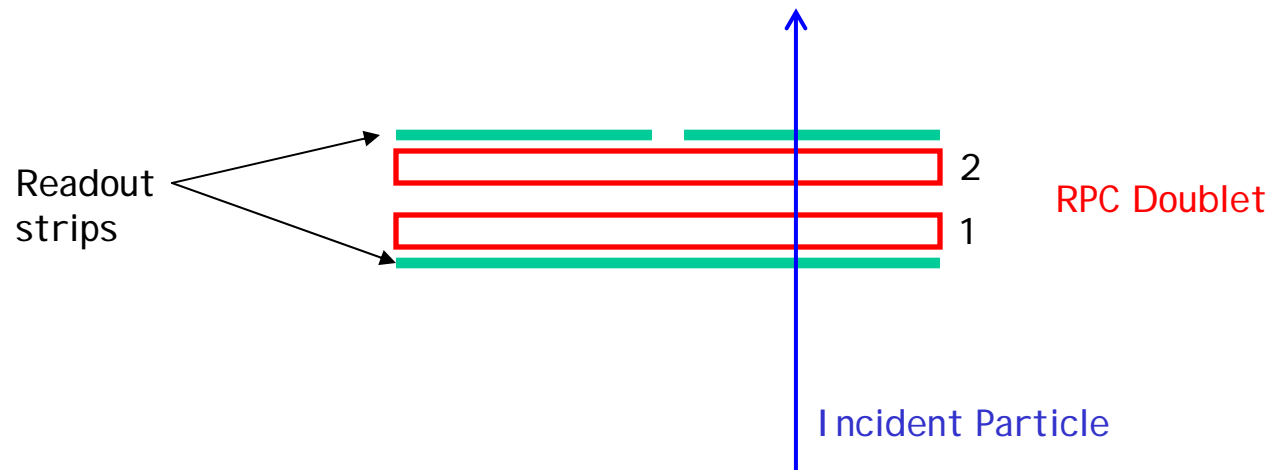


Based on measurements by Valeri on small chambers.



Cross talk is determined from the probability of a hit on strip 1 for a hit on strip 2 as a function of distance from strip 1

Cross Talk (cont.)



One can imagine that cross talk from direct induction goes as the solid angle ...

For each of the two RPCs:

Use probability curve on previous page for cross talk on the near readout strip.

For the far readout strip compress the horizontal axis by a factor of 2, i.e. the cross talk at 0.25 cm becomes the cross talk at 0.5 cm.

Cut on the following at ntuple level

- ≥ 1 reconstructed track in each view with reasonable χ^2
- Total Hits
- Length of electron candidate track in each view
- Ave. hits/plane for electron candidate track in each view
- Fraction of hits on electron candidate track/total hits
- Hits on electron candidate track in each view
- No more than 2 hits outside fiducial volume (50 cm in X & Y, 2 m in Z)

Use the following to form likelihood distributions

- Number of hit planes on electron candidate track
- RMS width distribution of electron candidate track
- Track angle with respect to beam direction
- Largest gap in electron candidate track
- Fraction of hits on electron candidate track/total hits
- Ave. hits/plane for electron candidate track in each view

Results

Liquid no ph				
	$\nu_{\mu} \rightarrow \nu_e$	ν_{μ} NC	ν_{μ} CC	Beam ν_e
Efficiency	0.14	0.002	0.0001	0.02
# of events	123	21.7	1.6	11.1
FOM	21.0			

RPC X or Y				
	$\nu_{\mu} \rightarrow \nu_e$	ν_{μ} NC	ν_{μ} CC	Beam ν_e
Efficiency	0.13	0.002	8×10^{-5}	0.02
# of events	112	19.8	1.1	13.1
FOM	19.2			

RPC X and Y				
	$\nu_{\mu} \rightarrow \nu_e$	ν_{μ} NC	ν_{μ} CC	Beam ν_e
Efficiency	0.15	0.0007	7×10^{-7}	0.024
# of events	133	7.6	0.01	15.1
FOM	27			

Summary

- RPC X or Y and liquid scint with no pulse height get consistent results.
- Results are not as good as RPC X and Y or liquid scint with pulse height, as expected.
- Study does not tell us much about a technology choice, but it would seem to indicate that no one is making any large blunders
- Algorithms being used are still somewhat primitive. More sophisticated algorithms will be developed over time and efficiencies and FOMs will improve.